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Analysis of the Effect Differences Between Neuroendoscopic Hematoma Evacuation and Minimally Invasive Drilling and Drainage in the Treatment of Patients with Spontaneous Intracerebral Hemorrhage

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Abstract: *Objective*: To compare and analyze the clinical effects of neuroendoscopic hematoma evacuation (ES) and minimally invasive drilling and drainage (MIDD) in the treatment of spontaneous intracerebral hemorrhage, as well as their impacts on neurological function and serological indicators. *Methods*: A retrospective analysis was conducted on 77 patients with intracerebral hemorrhage admitted to Gaoyou People's Hospital and Northern Jiangsu People's Hospital from January 2020 to December 2024. These patients were grouped according to their treatment methods, with 36 receiving MIDD (control group) and 41 receiving ES (experimental group). Perioperative indicators, neurological function before surgery and at 1 and 3 months postoperatively, and the incidence of complications during hospitalization and follow-up were compared between the two groups. *Results*: The experimental group had a longer operative time, greater intraoperative blood loss, a higher hematoma evacuation rate, and a shorter drainage tube placement time compared to the control group ($P < 0.05$). Compared to preoperative values, the Glasgow Coma Scale (GCS) scores of both groups continued to increase at 1 to 3 months postoperatively, with the experimental group showing higher scores; the National Institutes of Health Stroke Scale (NIHSS) scores of both groups continued to decrease, with the experimental group showing lower scores ($P < 0.05$). During hospitalization and follow-up, the overall incidence of complications was lower in the experimental group compared to the control group, but the difference was not statistically significant ($P > 0.05$). *Conclusion*: Endoscopic surgery (ES) for spontaneous intracerebral hemorrhage (ICH) can more thoroughly evacuate hematomas, improve neurological function, and shorten postoperative recovery time. Although it has drawbacks such as prolonged operative time and increased blood loss, its overall safety remains acceptable.

Keywords: Hypertensive intracerebral hemorrhage; Neuroendoscopy; Hematoma evacuation; Neurological function; Inflammatory response

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1. Introduction

Spontaneous intracerebral hemorrhage encompasses cerebral hemorrhages caused by various factors, including hypertensive intracerebral hemorrhage (HICH), vascular degeneration, vascular malformations, and other vascular diseases, representing one of the common clinical emergencies and critical conditions. It is characterized by sudden onset, rapid progression, and high rates of mortality and disability [1]. The formation of hematomas and their compression on surrounding brain tissue are significant contributors to secondary brain injury and neurological dysfunction, making rapid, safe, and effective hematoma evacuation a crucial step in improving prognosis [2]. Currently, commonly used surgical approaches include craniotomy for large bone flap hematoma evacuation (direct vision or microscope), minimally invasive keyhole hematoma evacuation (microscope), minimally invasive burr hole drainage (MIDD), and keyhole neuroendoscopic hematoma evacuation (ES), among others. Minimally invasive burr hole drainage is simple to perform and causes less trauma, but hematoma evacuation relies on repeated postoperative perfusion with thrombolytic drugs, resulting in low evacuation efficiency, a long duration, and difficulty in managing tough blood clots [3]. In contrast, keyhole neuroendoscopic hematoma evacuation, conducted under direct vision, can reduce secondary injury and theoretically achieve near-complete hematoma evacuation while significantly reducing the risk of complications [4]. In recent years, with the advancement of neuroendoscopic techniques, their application in the treatment of cerebral hemorrhage has gradually increased. Studies have found [5] that neuroendoscopic surgery demonstrates significant advantages in the treatment of cerebral hemorrhage. Its characteristics of minimally invasive surgery, high-definition surgical field, and precise operation endow it with distinct benefits in terms of hematoma evacuation rate, neurological function recovery, and complication control. However, the advantages in terms of efficacy and safety still require further validation. This study aims to provide evidence-based support for clinical surgical plan selection by comparing the differences between ES and MIDD in perioperative indicators, neurological function recovery, and complication rates.

2. Materials and methods

2.1. General information

A retrospective review was conducted on 77 patients with HICH admitted to Gaoyou People's Hospital and Northern Jiangsu People's Hospital from January 2020 to December 2024. The patients were grouped according to their treatment methods, with 36 undergoing MIDD (control group) and 41 undergoing ES (experimental group). Control group: age range 50–78 years old, mean age (60.91 ± 8.22) years old; 25 males and 16 females. Experimental group: age range 51–80 years old, mean age (61.23 ± 8.14) years old; 23 males and 13 females. There was no statistically significant difference in general information between the two groups ($P > 0.05$), indicating comparability. Inclusion criteria: patients diagnosed with spontaneous cerebral hemorrhage by imaging examination; those experiencing their first acute cerebral hemorrhage; those undergoing surgery within a time window of 72 hours from onset; and those with a hematoma volume generally ranging from 20 to 60 mL. Exclusion criteria: Patients with secondary intracranial hemorrhage; those with severe systemic diseases or a history of severe neurological conditions; and those with hematomas located in the brainstem that are life-threatening but unsuitable for minimally invasive surgery. The study complied with the requirements of the Declaration of Helsinki, and all patients provided informed consent.

2.2. Treatment methods

Both groups received routine symptomatic and supportive treatment upon admission, including absolute bed rest, blood pressure control, blood glucose and electrolyte balance regulation, dehydration to reduce intracranial pressure, prevention of stress ulcers and deep vein thrombosis, etc.

The control group underwent MIDD: Based on preoperative imaging, the central projection point of the largest hematoma section was marked on the scalp as the puncture target. After routine disinfection and draping, general or local infiltration anesthesia was administered. A straight incision approximately 3-5 cm in length was made, and the scalp was incised and retracted using a mastoid retractor. A single burr hole was drilled in the skull, and bone wax was used for hemostasis. The dura mater was coagulated in a cross shape with an electrocautery device and then incised. A silicone drainage tube with a stylet was slowly punctured to the center of the hematoma cavity. The stylet was removed, allowing dark red blood or blood clots to flow out. A syringe was connected for gentle and slow aspiration, with the initial aspiration volume not exceeding 40–50% of the total hematoma volume to avoid rebleeding induced by rapid decompression. Subsequently, the hematoma cavity was repeatedly and slowly flushed with an appropriate amount of normal saline (usually 3-5 ml each time) until the flushing fluid became clear. The drainage tube was left in the hematoma cavity, with the distal end brought out through a subcutaneous tunnel from another incision and securely sutured and fixed to the scalp. The original surgical incision was sutured. Continuous drainage is maintained after surgery, typically lasting for 3 to 7 days, with the timing of catheter removal determined based on the characteristics of the drainage fluid and the results of imaging follow-up.

In the study group undergoing ES: After general anesthesia takes effect, based on preoperative planning, a straight or small curved incision, approximately 4 to 7 cm in length, is made at the site closest to the cortex and avoiding functional areas of the hematoma. The entire scalp layer is incised, the periosteum is dissected, and the skull is exposed using a mastoid retractor. After drilling a hole in the skull with a cranial drill, a circular bone flap with a diameter of approximately 2 to 3 cm is removed using a milling cutter. The dura mater is incised in a cross or radial pattern and suspended. Under direct visualization with a microscope or endoscope, after coagulating the pia mater in an avascular area with electrocautery, a brain needle is used to puncture and explore the hematoma cavity. After confirming the depth and direction, a cortical fistula of approximately 1 to 1.5 cm is created along the puncture tract using bipolar electrocautery forceps and microscissors. The neuroendoscope is inserted into the hematoma cavity through a transparent sheath. Continuous irrigation with physiological saline is used to maintain a clear surgical field. Under direct endoscopic visualization, evacuation is performed: first, a suction device is used to aspirate liquid and semi-solid hematomas; for tough blood clots, they can be fragmented using endoscopic-specific tumor forceps and removed in pieces, or the "suction-drag" technique can be employed; during hematoma evacuation, bipolar electrocautery forceps are used at any time to coagulate and stop bleeding from active bleeding points or visible microvascular stumps. After satisfactory evacuation of the hematoma (> 80%), the endoscope is slowly withdrawn while carefully observing for any bleeding on the channel walls. Confirm the absence of active bleeding. In some cases, a drainage tube may be inserted, typically maintained for 1 to 3 days postoperatively. Finally, the dura mater is closed, the bone flap is repositioned, and the scalp incision is sutured. After surgery, both groups continue to control blood pressure, maintain water-electrolyte and acid-base balance, and prevent increased intracranial pressure. Continuous observation is maintained until discharge, with a 3-month follow-up period.

2.3. Observation indicators

(1) Perioperative indicators: The surgical time, intraoperative blood loss, hematoma clearance rate, and catheter drainage time were recorded for both groups. The formula for calculating hematoma volume is 1/2×a×b×c (where a, b, and c represent the maximum transverse diameter, longitudinal diameter, and slice thickness of the hematoma, respectively). Compared with the preoperative hematoma volume, the hematoma clearance rate was calculated as (preoperative volume - postoperative volume) / preoperative volume × 100%.

(2) Neurological function: Assessments were conducted before surgery, one month after surgery, and three months after surgery, including the Glasgow Coma Scale (GCS) [6] score, with a total score ranging from 3 to 15, where a higher score indicates better neurological function; and the National Institutes of Health Stroke Scale (NIHSS) [7] score, with a total score ranging from 0 to 42, where a higher score indicates more severe neurological deficits.

(3) Incidence of complications: The occurrence of rebleeding, intracranial infection, pneumonia, hydrocephalus, and deep vein thrombosis of the lower extremities during hospitalization and follow-up was recorded.

2.4. Statistical methods

Data were analyzed using SPSS 26.0 statistical software. Count data were expressed as [number of cases (%)], and the χ^2 test was used. Measurement data were expressed as mean ± standard deviation (SD), and the t-test was used. A P-value < 0.05 was considered statistically significant.

3. Results

3.1. Perioperative indicators

The experimental group had longer surgical duration, greater intraoperative blood loss, higher hematoma clearance rate, and shorter catheter drainage time compared to the control group (P < 0.05). See **Table 1**.

Table 1. Comparison of perioperative indicators between the two groups (mean ± SD)

Group	Number of Cases (*n*)	Operative Time (min)	Intraoperative Blood Loss (mL)	Hematoma Evacuation Rate (%)	Drainage Tube Indwelling Time (days)
Control Group	36	45.42 ± 15.36	62.61 ± 20.27	73.34 ± 8.52	5.21 ± 1.36
Experimental Group	41	78.17 ± 18.42	121.90 ± 18.63	88.62 ± 7.47	3.06 ± 1.12
t-value	-	5.838	7.562	8.386	7.605
P-value	-	< 0.05	< 0.05	< 0.05	< 0.05

3.2. Neurological function

Compared to preoperative levels, both groups showed a continuous increase in GCS scores and a continuous decrease in NIHSS scores from 1 to 3 months postoperatively, with the experimental group demonstrating higher GCS scores and lower NIHSS scores (P < 0.05). See **Table 2**.

Table 2. Comparison of neurological function between the two groups (mean ± SD, points)

Group	n	GCS			NIHSS		
		Before Surgery	1 Month Post-op	3 Months Post-op	Before Surgery	1 Month Post-op	3 Months Post-op
Control Group	36	7.28 ± 1.36	10.47 ± 2.15	12.03 ± 2.41	20.61 ± 3.84	14.39 ± 3.21	10.72 ± 2.65
Experimental Group	41	7.41 ± 1.42	12.15 ± 2.08*	13.92 ± 2.36*#	20.25 ± 3.57	11.82 ± 2.94*	7.61 ± 2.18*#
t-value		0.409	3.481	3.472	0.426	3.666	5.648
P-value		> 0.05	< 0.05	< 0.05	> 0.05	< 0.05	< 0.05

Note: Compared with preoperative levels, *$P < 0.05$; compared with 1 month postoperatively, $^{\#}P < 0.05$. GCS: Glasgow Coma Scale; NIHSS: National Institutes of Health Stroke Scale.

3.3. Comparison of blood pressure and incidence of complications between the two groups

During hospitalization and follow-up, the overall incidence of complications was lower in the experimental group (14.63%) compared to the control group (22.22%), but the difference was not statistically significant ($P > 0.05$). See **Table 3**.

Table 3. Comparison of incidence of complications between the two groups [cases (%)]

Group	Number of Cases (*n*)	Re-bleeding	Intracranial Infection	Pneumonia	Hydrocephalus	Lower Limb DVT	Total Incidence
Control Group	36	2 (5.56)	1 (2.78)	2 (5.56)	2 (5.56)	1 (2.78)	8 (22.22)
Experimental Group	41	1 (2.44)	1 (2.44)	2 (4.88)	1 (2.44)	1 (2.44)	6 (14.63)
χ^2-value							0.742
P-value							> 0.05

4. Discussion

The pathological basis of intracerebral hemorrhage encompasses not only the space-occupying effect and local compression caused by the hematoma but also involves neurotoxicity induced by hematoma decomposition products, inflammatory responses, and damage to the blood-brain barrier, which subsequently lead to secondary brain tissue damage and neurological dysfunction. Traditional craniotomy is highly invasive, while conservative treatment has limited effectiveness for moderate to large hematomas. In this context, minimally invasive intracerebral hematoma drainage (MIDD) emerged, which significantly reduces surgical trauma by establishing a physical channel to drain the hematoma, providing surgical opportunities for elderly and high-risk patients. However, MIDD has limited hematoma clearance rates, and residual hematomas can prolong the recovery time of neurological function and increase the risk of secondary complications. Additionally, the prolonged catheter drainage time makes it difficult to fully reflect the impact of surgery on inflammatory responses and neural repair [8]. Therefore, finding a surgical approach that can improve clearance rates, shorten recovery periods, and alleviate inflammation and promote neural repair at the molecular level has become a clinical focus.

The hematoma clearance rate directly affects the degree of compression on surrounding brain tissue and the occurrence of secondary cerebral edema. The more thorough the hematoma clearance, the faster the restoration of blood flow and cerebral perfusion pressure in the surrounding tissues. Endoscopic surgery (ES) allows for precise manipulation and piecemeal aspiration under direct vision, minimizing damage to surrounding normal brain tissue. It also has a low residual hematoma rate, reducing secondary neurological damage and dependence on cerebrospinal fluid drainage [9]. Moreover, due to the quicker alleviation of brain tissue compression, there is less edema and secondary inflammation caused by residual hematoma. Consequently, the duration of intensive care for patients is correspondingly shortened, and the quality of neurological functional recovery is higher [10]. Studies have demonstrated the efficacy and safety of neuroendoscopic treatment for intracerebral hemorrhage [11]. A meta-analysis comparing small bone window craniotomy microsurgery with neuroendoscopic surgery for intracerebral hemorrhage revealed that neuroendoscopic treatment resulted in a higher hematoma clearance rate, less intraoperative bleeding, shorter operation time, fewer days in the intensive care unit, a lower incidence of postoperative complications, lower NIHSS scores at 3 months postoperatively, and higher scores in activities of daily living [12].

The results of this study showed that, compared with the control group, the experimental group had a higher hematoma clearance rate, shorter catheter drainage time, higher GCS scores, and lower NIHSS scores 1 to 3 months postoperatively. These findings suggest that the application of ES in patients with intracerebral hemorrhage can enhance hematoma clearance, shorten postoperative recovery time, and promote neurological functional recovery. However, in this study, the experimental group had longer operation times and greater intraoperative blood loss compared to the control group. The reasons for this are that ES requires the gradual removal of the hematoma layer by layer under direct vision, along with meticulous hemostasis. The procedure is delicate and involves multiple steps, resulting in significantly longer operation times than MIDD. At the same time, although direct visualization can improve clearance precision, the exposure of the hematoma and surrounding tissues, as well as the passage of surgical instruments through brain tissue, may damage small blood vessels, leading to increased intraoperative bleeding.

Studies have found that ES can alleviate the mechanical compression of surrounding brain tissue caused by residual hematoma and the toxicity of hematoma decomposition products, reduce local inflammatory responses, improve cerebral perfusion, optimize the microenvironment, and provide a physiological basis for the release of anti-inflammatory factors. This further protects the surrounding brain tissue, allowing the inflammatory and repair mechanisms to be more fully exerted, thereby creating a virtuous cycle [13].

In the results of this study, during hospitalization and follow-up, the overall complication rate in the experimental group was lower, but the difference was not statistically significant compared to the control group. The analysis suggests that ES reduces the risk of postoperative secondary infections, hydrocephalus, and other complications by precisely removing hematomas, minimizing brain tissue damage, and reducing residual hematoma. Therefore, the overall complication rate is lower. Although MIDD is minimally invasive, its low hematoma evacuation rate and prolonged catheterization time may increase the risk of infection and hydrocephalus. Due to the limited sample size, although the overall complication rate in the experimental group was lower than that in the control group, the difference did not reach statistical significance, necessitating further validation through large-sample, multicenter studies.

5. Conclusion

In conclusion, ES treatment for cerebral hemorrhage can more thoroughly evacuate hematomas, reduce inflammatory responses in patients, improve neurological function, and shorten postoperative recovery time. Although it has drawbacks such as prolonged operation time and increased blood loss, its overall safety is acceptable.

Disclosure statement

The authors declare no conflict of interest.

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